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ABSTRACT

This paper overviews strategies employed by the Appalachian Rural Systemic Initiative (ARSI) to implement systemic reform in math, science, and technology education in rural Appalachia. ARSI is one of four Rural Systemic Initiative projects funded by the National Science Foundation to target regions characterized by low population density and high levels of poverty. The initiative targeted 66 counties encompassing 89 school districts in Kentucky, North Carolina, Ohio, Tennessee, Virginia, and West Virginia. The ARSI project is based on two fundamental strategies: school and community-based action and technology as a tool for access. Specifically, the initiative involved the creation of six regional resource collaboratives made up of key organizations such as universities and community colleges, business and industry, federal and state agencies, teacher enhancement projects, exemplary schools, and community development organizations. The collaboratives allow educators and communities to access curricular and instructional resources, technical assistance, professional development, and other services through technology. Other strategies involved helping counties locate funds to establish the necessary infrastructure for technology use; providing funds for designated teacher-partners to learn standards-based instructional techniques and for school-based professional development opportunities; assisting designated schools in establishing a community engagement team to develop and implement an action plan for improving student achievement; and providing direction and support to catalyst schools that serve as a springboard for the reform process. This report addresses issues related to project implementation and contains references, suggested readings, and Web sites for rural educators. (LP)

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Strategies for Improving Math and Science Achievement in Rural Appalachia

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STRATEGIES FOR IMPROVING MATH AND SCIENCE ACHIEVEMENT IN RURAL APPALACHIA

Much of the education reform movement in the 1980s bypassed small schools and communities located in Rural America. By the late 1980s, however, rural schools began to receive attention. In 1987, Congress directed each of the regional educational laboratories to develop a "rural initiative." As a result of this action, in 1991 the U.S. Department of Education directed that the laboratories devote 25 percent of their effort to helping rural schools by fostering innovative rural education programs that promise to improve instruction, and by building the capacity of state and local educators to respond to the changing needs of rural students and communities. In essence, rural schools were on the road to reform (Lewis, 1992).

Appalachia, an impoverished area of the U.S. hoping to not repeat the status of being left behind a generation earlier in the creation of a modern interstate highway system, joined the education reform agenda. In his article "On the Road to Excellence in Education," Hoffman (1993) describes three of the 17 innovative educational programs funded by the Appalachian Regional Commission (ARC) and the Southern Governors' Association. The projects were designed to meet at least one of the four National Education Goals important to ARC: school readiness, adult literacy and lifelong learning, math-science education, and dropout prevention.

Education reform in Appalachia, however, faces many challenges. The customary characteristics of small scale, isolation, and sparsity in rural school districts are difficult to overcome. The report "Education Reform in Rural Appalachia" (Brizius, J. A. , Foster, S. E. , & Patton, H. M., 1988) describes how rural schools in Appalachia face scarcity because of poverty, a weak tax base, and insufficient state and federal aid. The authors conclude that rural schools in Appalachia exhibit several characteristics that set them apart from other schools and that may influence the ways in which statewide reforms affect schools, students, and their rural communities. Rural schools of Appalachia, according to the report, are more influenced by the economic and cultural outlooks of their communities than other schools; they reflect and shape the economic and social stratification of their communities; they embody pride in values, including discipline and hard work; they serve as more than just classrooms, but also as cultural and social centers of small towns and rural life; and they are often the major link between the community and the world. The authors also reveal a major barrier to improving student achievement and school success:

> Perhaps the most profound scarcity in some rural communities is one of hope for economic renewal, rooted in the lack of concrete economic rewards for academic achievement. In

> some communities, the lack of a clear and compelling link between education and economic opportunity erodes the motivation of students and challenges the schools as they attempt to improve student performance and reduce dropout rates. (p. iv)

In an issue of the *Phi Delta Kappan* devoted to the theme of rural education, Seal and Harmon (1995) point out the realities of rural school reform in a state with all counties in Appalachia:

> The idea of making high fliers out of students who are low academic achievers living in places that are considered educationally and culturally deprived--such as rural Appalachia--warms the hearts of those who see education as the road to economic well-being for the nation. However, the education reform rhetoric that sounds so good from afar must be sold from the local courthouse steps and in the school auditorium to rural residents who distrust outsiders with big plans for making "deprived" people want to be "middle class." (p. 119)

The commitment to improve the mathematics and science of students in Appalachia has never been higher, perhaps because it has become increasingly clear that in an information age the future economic prosperity of the region and its people depends on the quality of education available and mastered--throughout one's lifetime. And mastery of high quality math and science leads the agenda of local education reform initiatives in many schools of Appalachia. Examples of initiatives include standards-based microscope lessons for middle school students (Bowman, 1996), student investigation of local environmental issues (Bousquet, 1993), "mountain science" for rural adults (Kimmons, 1995), hands-on science by museums that introduce students to science (Casto, 1994), mathematics activities manuals for students in grades 5-8 (Childers & Howley, 1993), and an early childhood teacher enhancement mathematics project funded by the National Science Foundation (Kwartler, 1993).

In 1994, the National Science Foundation (NSF) expanded its commitment to ensure all students have access to high quality standards-based math and science by creating a new rural initiative to complete its educational systemic reform trilogy. Joining the Statewide Systemic Initiatives and Urban Systemic Initiatives, the Rural Systemic Initiative (RSI) targets those regions of the nation that are characterized by low population density and high levels of economic poverty. The RSI is unique among the trilogy of educational systemic reform efforts in that the "regions" are not defined political geographic structures, but rather are determined by a collaborative effort of partners who share a vision of educational reform in school districts that have similar backgrounds and cultures and face common educational and economic barriers. NSF funded four Rural Systemic Initiative implementation projects in October 1995. One of these was the Appalachian Rural Systemic Initiative (ARSI).

This paper describes the ARSI approach and strategies for creating systemic reform in math and science and lists lessons learned from early implementation efforts. Suggested readings and selected web sites for rural educators conclude the paper.

ARSI: Briefly Described

The Appalachian Rural Systemic Initiative (ARSI) is a collaborative effort among six states in Central Appalachia – Kentucky, North Carolina, Ohio, Tennessee, Virginia, and West Virginia – to stimulate sustainable systemic improvements in science, mathematics, and technology education for K-14 students. Its target region in those six states encompasses the 66 Appalachian counties that meet the criteria established by NSF for the Rural Systemic Initiatives program – Beale Codes 6-9 and at least 30 percent of school-age children living in poverty. These are distributed among the states as shown in the table below:

	KY	NC	OH	TN	VA	WV	TOTAL
ARSI counties	35	2	5	7	3	14	66
School districts	46	3	12	10	4	14	89
Schools	323	12	66	72	41	210	724
Teachers	4,786	295	764	1,679	1,219	4,124	12,867
Students	130,453	3,353	17,448	26,543	15,744	58,210	251,751

The principal goal of the Appalachian Rural Systemic Initiative is to accelerate performance in science, mathematics, and technology for all students in its target counties.

ARSI's Systemic Approach

Traditionally, educational reform has been pursued via three general strategies: fix the parts, fix the people, or fix the school (Sashkin and Egermeir, 1993). Systemic reform, by contrast, encompasses the need for coordinated change strategies, where attention is given simultaneously to issues of policy, resources, curriculum, instruction, assessment, professional development, equity and articulation – systemic factors that operate at the school level to impact learning environments. The approach during ARSI's implementation is systemic, involving changes in institutional roles and relationships that impact classroom instruction, policy-making, community involvement, and post-secondary transition. It builds upon existing reform initiatives and enlists the energies of local, state and regional partners – businesses, higher education, community groups, and public agencies. Such a range of stakeholders and participants is critical in achieving

a balance of bottom-up and top-down strategies in which district and school-level leaders set directions and expectations; teachers use their experience, innovation, and commitment to create effective implementation; and external groups provide needed services and supports.

ARSI's systemic approach includes attention to realities of the Appalachian Region, including student access to equitable educational opportunities and delivery of a standards-based mathematics and science curriculum. The region is characterized by challenges that do not respect state boundaries. Geographic isolation, persistent poverty, low population density, underdeveloped infrastructure, and limited economic opportunities are common across the 233 Appalachian counties in the six states. The commonalities in the fundamental challenges facing education in Appalachian communities indicate the need for a coordinated regional approach, enabling the targeted counties to utilize the resources that exist in each state to support systemic reform.

The "bottom line" for the ARSI is improved performance in science and mathematics by all students. "Improved performance" means that students have acquired the scientific and mathematical knowledge, academic and technological skills, and "habits of mind" necessary to function as productive workers, contributing community members, and self-sufficient individuals, including the opportunity to pursue careers in math and science-based fields. The ARSI approach emphasizes that Appalachian students must achieve the same high standards and meet expectations being set forth for the nation as a whole. Professional standards for mathematics and science education produced by NCTM and NRC provide the national benchmarks against which curriculum, instruction, and assessment in American schools are evaluated. *The ARSI's challenge is to stimulate reform of the educational system in Appalachian school districts to produce a learning environment that expects and enables achievement of high standards by all students.*

Initial planning activities for the ARSI revealed improving mathematics and science achievement in the region would require the initiative to address need for a local vision; need for enhanced capacity; and need for access to resources, services and supports.

Many Appalachian schools and communities need assistance in developing a vision for mathematics and science. Such a vision might include: the importance of math and science to employability and economic growth; characteristics of math and science education; role of technology; and the nature of community involvement and support for schools.

Capacity is the key to sustaining systemic change. While pockets of innovation exist, Appalachia lacks the capacity to translate these isolated successes into regional impact. For example, data collected on planning the ARSI revealed less than 30% of teachers report having access to a curriculum consultant in math or science; 32% lack access to a staff member to help with technology; 47% lack equipment needed for hands-on learning; and 47% of school administrators report that their school lacks a plan for using technology in math and science. The region needs strong leadership and more local expertise to support desired changes in education

and practices.

Appalachian counties also lack access to information and expertise that are readily available to suburban communities in the states. For example, 64% of teachers report that their instructional materials do not adequately reflect national standards; only 46% are comfortable using technology; and administrators report that professional development has not adequately addressed standards-based learning in math (32%) and science (46%). Access is needed to high quality learning resources; professional growth experiences; ongoing technical assistance and follow-up support; and models/exemplars of success.

ARSI Strategies

To address these needs, the ARSI plan is based on two fundamental strategies: (1) school and community-based action, and (2) technology as a tool for access.

School and community-based action. Assistance and support for Appalachian schools and communities must be based on locally-identified needs, rather than an external determination of problems. Rural communities are typically reluctant to follow outside persons or programs purporting to know how to "help" them. A key learning from the development process is that rural schools, while resource-poor in comparison with other schools, nevertheless can make significant impact on student learning by coordinating use of their resources toward strategically-identified problems. The ARSI utilizes local persons to lead local efforts – growing leaders from within the school and community in order to maintain local buy-in and sustain long-term efforts. At the community level, the ARSI links resources, people, and organizations in sustained collaboration to develop the vision, leadership, and commitment for school improvement. At the school level, the ARSI helps teachers and administrators develop the knowledge and skills needed to make sound decisions about curriculum, instruction, assessment, student placement, and other critical issues. At both levels, the focus is on increasing the mathematics and science performance of *all* students.

Technology as a tool for access. NSF and the U.S. Department of Education (1995) state that "the appropriate use of technology can improve teaching and instruction; expand and enrich learning opportunities; support systemic change; link schools and learning sites to the broader society; and provide equal access to educational opportunities." Moreover, "information technologies can provide tools that enable all learners, regardless of location and socioeconomic status, to access resources, information, experts, mentors, and colleagues." The rapidly-growing capabilities of high-speed networks and telecommunication systems give rural regions their first real potential to overcome the persistent isolation and lack of opportunity resulting from geography and poverty. The information highway is an equitable link to high quality curriculum resources; expert assistance; sharing of ideas among colleagues; and distance learning for classroom instruction and professional development. The six ARSI states are making significant investments in technology and many schools in the 66 eligible counties will have Internet access

making a technology-based strategy feasible. Presence of technological capability in schools also opens possibilities for community development applications.

While these strategies are seen as the key leverage points for change, it mus: be noted that *systemic change in Appalachia is a long-term effort. Outcome measures of the ARSI implementation are necessarily intermediate in nature, demonstrating a trajectory toward long-term success.* The limited NSF/RSI funds are used to catalyze and leverage existing and new resources to support enhanced student educational opportunities and achievement in math and science.

ARSI Resource Collaboratives – Regional Support for Local Improvement

The concept of the ARSI Resource Collaborative is expressed in the conclusion of the Education Committee of the Kentucky Appalachian Task Force (1995) that Appalachia:

> ...needs a regionally specific education innovation center that works with, receives support from, but is administratively outside existing bureaucracies. The focus of the center would be on student programs, the professional development of teachers and other educators, and the integration of community . . . its activities would be spread throughout the region in all parts of the participating counties and not just 'population centers.' Activity would be student-centered and project-oriented. The center would be structured so as to be accountable to communities and in particular the children of our communities." (p.28)

The ARSI Resource Collaboratives--six now exist--represent a significant and ongoing mechanism through which educators and communities can access curricular and instructional resources, technical assistance, professional development, professional interactions, and other products, services, and supports. ARSI Collaboratives are a customer-driven *network of partners* whose mission is to empower educators and communities through coordinated access to physical, human, and organizational resources. Partners include key organizations and initiatives in a region, such as universities and community colleges, business and industry, federal and state agencies, NSF SSI and Teacher Enhancement projects, exemplary schools, and community development organizations.

Collaborative activities are divided into two major strands: Learning Support and Community Engagement. *Learning Support* functions of the Resource Collaborative are designed as "instructional partners" to enhance the effectiveness of teaching and learning environments in ARSI-participating schools. They give teachers and students ready access to information, ideas, professional interactions, and technical support. Some Resource Collaborative activities are designed around common needs and operated for all teachers or students in the region; other activities are conducted in response to a specific need or request of a

student, teacher, or administrator. In each case, the activities use Resource Collaborative partners to connect educators with the means to enhance student learning.

Resource Collaboratives engage in both development and outreach-and-support activities. *Development* activities involve identifying, compiling, and in some instances generating resource materials for quality math and science learning. The Collaborative Director identifies outstanding university faculty, teacher educators, and classroom teachers from among the partners, using their ideas and expertise to identify, adapt and develop needed materials. Using exemplary national curricula and electronic databases such as the Eisenhower National Clearinghouse, the Collaborative adapts proven resources to the contexts of rural schools in the ARSI states.

Outreach-and support activities provide learning opportunities for students and teachers, as well as ongoing support for educators as they improve their math and science programs. Some activities occur *on-site*, providing specific training, consultation, or follow-up support for implementing ideas. Other activities are conducted *regionally*, typically professional development institutes, with open access to educators in ARSI counties. Still other activities take place *on-line*, where teachers or students use Internet access to take part in learning activities, to exchange ideas, or to search for particular information or resources

A critical feature of the learning support function of each ARSI Resource Collaborative is its technology connection to the "information highway." Availability of instructional resources, professional development, technical assistance, and networking via the Internet is seen as a central strategy for providing rural schools with equitable access and opportunities to support change. A major focus for the first year of ARSI implementation was to assist counties in establishing that infrastructure through a combination of existing state efforts and pursuit of additional funding and support. Interim strategies, such as providing toll-free dial-up access and conducting more on-site consultations and trainings, will be utilized until the necessary connections are in place. Moreover, other classroom applications of technology, such as use of laboratory probes, simulation software, graphics calculators, videodiscs, and CD ROM, will be promoted through professional development and on-site follow-up assistance and support.

ARSI's implementation strategy includes the establishment of Resource Collaboratives at higher education institutions that develop an instructional partnership with math and science teachers. ARSI also provides funds to districts to release a math or science teacher half time to provide daily support for an entire school faculty. These ARSI Teacher Partners become the critical link between a vast awry of resources and change in classroom instruction.

ARSI Teacher Partners are released half time to assist math and science teachers in the transition to standards-based curriculum and assessment, and inquiry based instruction. These teachers meet with ARSI Resource Collaborative staff monthly to learn standards-based instructional techniques. Teacher Partners then provide school-based professional development and team teaching every day through the entire academic year. Teacher Partners are also the link between local, state, regional, and national resources specific to math and science instruction.

A special initiative of the ARSI, working through the Resource Collaboratives, is designed to enhance teaching and learning at *community colleges* in the region. Community colleges are a vital link between schools, communities, and employment opportunities in Appalachia. However, community college faculty are in need of training in instructional methods and course structures that promote success in a broader range of students. A highly successful teaching model, called The Excel Program, was developed at the University of Kentucky. Excel uses cooperative groups in problem-solving sessions to achieve successful student learning in mathematics and science, particularly among females and minorities. The Excel model will be disseminated through faculty training and financial support to enhance skills of community college instructors, as well as to provide a more effective learning environment in math and science for students entering post-secondary studies.

Community Engagement functions of the Resource Collaborative are designed to build community readiness and school leadership to support and sustain the implementation of quality science and math instruction. Based on information from the ARSI development period, Appalachian communities are generally supportive of their schools, but typically have not engaged in the dialogues needed to build a community vision of their schools and a true commitment to quality education. Nor have formal linkages been established to provide ongoing interactions between the school staff and stakeholders (parents, businesses, community agencies) in the community as a whole. As at the school level, the challenge is to build the vision, leadership, knowledge, skills, and resources to enable the community to make sound choices about its children's educational outcomes.

ARSI staff work with school district leadership and Resource Collaborate partners in the region to target schools with a high interest in engaging their communities in meaningful ways to support math and science achievement of students. All school districts in the 66 ARSI target counties are eligible to establish a school to receive ARSI assistance. ARSI staff assist the school in establishing a community engagement team, in selecting a team facilitator, and in carrying out activities and accessing resources to develop and implement an action plan. Each team completes an assessment of community resources and rates a set of indicators that allow the team to establish benchmarks regarding student achievement in math and science and related community support. Indicators include both those considered essential by NSF and those the team thinks appropriate on the school's and community's agenda for school improvement. Action plan activities target the indicators rated lowest by the team and/or focus on strategic opportunities available for the team to impact student achievement. Leadership and team building skills are offered for facilitators and team members through regional institutes. Lastly, the team periodically conducts a self-assessment of progress and measures success based on the established benchmarks.

Resource Collaboratives seek to connect the team to resource partners who can assist the team in implementing activities in the action plan. Facilitators are also connected electronically via Internet to share strategies for making the community engagement component successful. As the team strives to impact community involvement and student achievement in the school, district level leadership and ARSI staff begin concentrating on ways to scale-up the community

engagement concept of ARSI to other schools in the district. Schools are mapped onto an ARSI community engagement wall chart for assessing scale-up and sustainability progress and potential in the school district. The targeted school for stimulating meaningful community engagement in the district may or may not be the same school that is receiving intense assistance from ARSI staff to implement the learning support component.

Catalyst Schools

ARSI's Resource Collaboratives carry out its strategic capacity building functions by working first in one school of a targeted school district--one that is considered "ready" to accept and implement the concept of systemic reform. This one school, called a "catalyst school," serves as the springboard for the reform process in the district by developing local leadership capacity and active community support, and by demonstrating the impact of a standards-based approach to learning science and mathematics.

During its first year, ARSI developed a framework to assist in determining districts' and schools' "readiness" to participate in ARSI local and regional initiatives. The framework focused on two factors as particularly important – level of technology implementation and availability of persons to support science, mathematics, and technology implementation. Based on information provided by the districts, ARSI personnel assessed the "readiness" of districts and schools. As a result, schools in 21 of the 66 ARSI counties were selected as "catalyst schools" to begin intensive local leadership and community engagement development. At the same time, a menu of diverse programs and services was identified to enhance the readiness status of other ARSI schools. These activities to be offered by the resource collaboratives include: assisting in development of school improvement and technology plans; providing training for local technology coordinators; writing grant proposals; conducting technology workshops for administrators; and offering resource awareness workshops, including information and hand-on opportunities to enable educators and community engagement team members to access resources via the ARSI webpage.

Catalyst schools contain several entities with which ARSI works in an ongoing manner. Each is critical to building the capacity of the local system to support and sustain implementation of equitable, standards-based mathematics and science.

- *Teacher Partner.* The designated Teacher Partner serves as a school-based instructional partner and resource person, with release time to engage in leadership development as well as to provide continuous, on-site support to colleagues at the school. Teacher Partners are not "trainers;" rather, they provide mentoring, resource awareness, and other assistance to classroom teachers working to change their instructional practices.

- *Technology Coordinator.* The school or district-based Technology Coordinator works with Resource Collaborative personnel to enhance the availability and use of technology in support of science and mathematics learning.

- *Community Engagement Team & Facilitator.* The Community Engagement Team is locally-identified, and consists of 6-10 parents, business persons, community representatives, teachers, and (in some cases) students. Led by a Community Engagement Facilitator, the team engages in activities to develop an action plan, to build understanding and support for quality mathematics and science among community members, and to continuously assess team results based on benchmarks set for indicators, as well as to foster increased community involvement in the school reform effort.

- *District Liaison.* The District Liaison is a person in the district office who is the key to scaling-up the impact of changes in the catalyst school to other schools in the district, through involvement in professional development planning, resource allocation, and curriculum/instruction support.

In essence, the catalyst schools, working closely with their respective regional resource collaborative, provide the laboratory in which ARSI works to build local capacity and to link local reform to regional and national resources. As their name implies, their development also catalyzes change throughout the school district, and is an important component of ARSI's strategy for scale-up.

Lessons Learned

We offer the following "lessons learned" from our experiences in implementing the ARSI, clearly recognizing the initiative is in early implementation stages. Such observations, however, may prove to be valuable for others who seek to implement systemic reform in rural communities.

1. Persistent efforts will be needed to ensure math and science is the main focus of the initiative, as the current excitement, advocacy and expectations among educators regarding technology may overshadow attention to other barriers to students taking and achieving in standards-based math and science.

2. Accountability demands on school system administrators for immediate results in student achievement will place enormous pressure on project personnel to delivery needed technical assistance to schools that exceeds initial capacity of the initiative.

3. Evaluation design and data collection strategies must begin during the planning stage of the initiative, and consider that rural schools have very limited capacity to handle "additional paper work."

4. Initiatives involving several states must seek a strategy that allows comparison of student achievement results in the region without expecting any state to add a new and different test to its state testing program.

5. The project director must diligently and continuously advocate a consistent vision and staff focus for effective implementation of a regional multi-state initiative.

6. School leaders with a negative attitude toward or past experiences in community involvement should not be expected to form a credible community engagement team.

7. Completing the community self-assessment profile, setting benchmarks by rating results indicators, and developing the action plan will be labor intensive and critical for measuring success of the community engagement strand of ARSI at the school level.

8. Resource Collaboratives must seek to meaningfully involve other regional educational service providers early after the collaborative is established.

9. Establishing Resource Collaboratives at a university can be a slow process.

10. Building school-level capacity for long-term change and sustainability through Resource Collaboratives connecting with Teacher Partners, Technology Coordinators, and Community Engagement Teams can intensely focus rural schools on student achievement and related instructional improvement challenges.

11. Applications of technology can address isolation of rural teachers but networking through technology must be facilitated initially on a regular basis.

12. Teacher Partners, linked to value-added resources on a well organized web site, can favorably impact instruction and enhance math and science teachers' transition to inquiry-based instructional practices aligned with standards-based curriculum frameworks.

13. Releasing a teacher half time can be an extremely efficient way to impact all teachers in a school across the entire curriculum for a full academic year.

14. "Success stories" and advocacy for the initiative will need to favorably impact a large percentage of educators, parents and community members before a school district leader can be expected to address changing policies and leveraging existing funds to support the project.

15. It takes "grassroots" involvement and support for maximizing the relevance of student achievement in math and science to local community and economic development.

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Web Sites for Rural Educators

Appalachian Rural Systemic Initiative (ARSI)	http://starbuck.ced.appstate.edu/arsi
National Science Foundation (NSF)	http://www.her.nsf.gov
Explorer	http://explorer.scrtec.org/explorer
Eisenhower National Clearinghouse (ENC) for Mathematics and Science	http://www.enc.org
The Rural Center at AEL	http://www.ael.org/rel/rural/index.htm
The Why Files	http://whyfiles.news.wisc.edu